COMPARING IMPLICIT AND EXPLICIT WATER PRICES DURING THE EARLY YEARS OF WATER TRADING IN AUSTRALIA

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ABSTRACT

This paper examines aspects of changes to explicit and implicit water prices during the early years of water trading along the River Murray. Focusing on the mid to late 1990s, it traces price changes that occurred during the transition from an 'immature' market, where the supply of unused water influenced sales, to an early maturing stage where sales of water from inefficient to more efficient users begins to increase. Importantly, the time period used precedes the date at which land and water rights were formally separated in title and therefore covers a period where land was transacted with the value of the water embedded in the price. Hedonic functions are used to analyse the transactions of irrigated farmland to identify the implicit price of water when sold together with irrigated farmland and compare these to the explicit price paid for water entitlements in the water market. This comparison is conducted separately for three states. There is tentative evidence to suggest that: 1) prices in the two markets tended to converge; 2) the convergence process varies between states depending on how long the entitlement market has been in operation and the type of major water use; and 3) the more capital intensive the production and the more it is based on permanent crops, the more the implicit price is linked to investments in water dependent improvements.

Keywords: Water entitlements, water trading, water prices, water value, price convergence

INTRODUCTION

The National Water Initiative (CoAG, 2004) requires all states to separate formally water entitlements from the land to which they have traditionally been appurtenant. It also establishes that separate registers have to be established for the water entitlements, ultimately with the same qualities as the Torrens Land Title system. This separation has some quite profound implications for the property professions, not least property valuers assessing irrigation properties for rating, taxing or lending purposes (Bjornlund, 2008a,b). Under the new policies, rating and taxing valuers have to separate the value of the land from the value of the water entitlement, as they are now a separate chattel and hence is not taxable when sold. Banks have to consider their separate values, as they must take out separate mortgages for the land and water assets.

One simple method of calculating the separate value of the water would be to multiply the going price of water entitlements in the water market with the volume of water attached to the land to estimate the total value of the water, and then subtract this from the estimated value of the land and water as traditionally valued. Unfortunately, the final estimate would only be correct if the Law of One Price applied; that is, that the price of water attached to land had the same price as water traded as a separate commodity.

With water markets in place, long-term entitlements to water can be purchased in two different markets: (i) the market for water entitlements; and (ii) the land market where the entitlement is traded as part of an irrigated farm. As markets mature, the price of water entitlements in the two markets should converge. When the prices converge or when the price in the water market exceeds the implicit price in the land market, then the prices paid for water entitlements in the water market will compensate the sellers for any loss in property value they experience as a result of the sale.

As a consequence of the separation of land and water rights, many appraisers making estimates for rating and taxation purposes now have to separate the land and water values. If water prices in the two markets do not converge, then water market prices cannot be used when separating the value of the water component from the traditional land value. Under these circumstances, information about the implicit price of water could, instead, form the basis for such separate valuations.

This paper compares the explicit price of water entitlements paid in water markets with the implicit price paid for water when purchased as part of an irrigated farm. This implicit price has been extracted from transactions of irrigated farmland using hedonic functions. The issue of price conversion between implicit and explicit prices will then be explored within three Australian states (South Australia, Victoria and New South Wales) to see how price convergence varies between states and explore the factors which might cause such variation. During the mid to late 1990s, when the markets were still developing in all three states, most water entitlements were still traded in the irrigated land market while the volume traded in the entitlement market was slowly growing (Bjornlund and Rossini, 2008). Hence, this period provides a unique opportunity to observe the convergence of implicit and explicit water prices.

THEORETICAL BACKGROUND

Water markets, based on secure property rights in water, have been promoted as the means to manage existing supply and 'allocate available resources between competing users' for quite some time (Randall, 1981). At first glance, it would seem reasonable to assume that such a good would be relatively homogenous; that for all water users along the River Murray willing to purchase water, there is one uniform good for sale – water. In fact, the product for sale along the River Murray is a relatively heterogeneous commodity. Most importantly, the bundle of rights associated with an entitlement of one mega-litre (ML) of water varies significantly from state to state and a total of 438 different water entitlements exist with very different levels of reliability of supply. Water quality also varies along the length of the river, with purchasers downstream only able to access water of lower quality (i.e. with increased salinity or pollutants), than purchasers higher upstream. This suggests that regional markets are likely to dominate.

With the introduction of water markets, and before the formal separation of land and water title, three distinct markets for water exists: (i) the market for entitlements (W_E) in which the long-term entitlements to receive seasonal allocations are traded; (ii) the market for water allocations (W_A) in which the use of the seasonal allocations yielded by the entitlement is traded, while the entitlement remains the ownership of the seller; and (iii) the market for irrigated farmland; where water entitlements are traded as part of a package of assets (W_L). In this paper, the focus is on W_E and W_L.

Trading in water entitlements was introduced first into South Australia in 1983, then into New South Wales in 1989 and into Victoria in 1991. Although community concern about the potential social impact associated with entitlement trading delayed the introduction of entitlement markets in NSW and Victoria, in South Australia the demand for water for new major horticultural developments placed significant pressure on the State Government to introduce entitlement trading earlier than in other states, where production was less capital intensive (Bjornlund and McKay, 2000). By the mid to late 1990's, these markets were operating in the three states in varying degrees of maturity.

As water markets mature, as the total demand for water grows, as the competition for water among users intensify, and as externality problems become pressing, the attributes and behavior of water markets should become more predictable (Randall, 1981). This does not mean that the price of water will necessarily be more predictable in the short-run, but rather that the factors which impact on price and quantity, such as the response of buyers to changes in supply; the impact of variation in crop prices, and the treatment of water as a production input, will be more in accord with basic market principles (Bjornlund, 2003a,b,c, 2006a.b; Bjornlund and Rossini, 2005, 2007, 2008; Wheeler et al., 2008a,b,c). In the period under review, however, the water markets were still 'emerging'; particularly in Victoria and NSW. Markets for entitlements were dominated by 'unused' water (water not linked to productive use and thus effectively surplus) (Bjornlund and McKay, 2000). Over time, as the majority of unused water entitlements are sold, it is likely that there will be less unused water and more 'used' water traded; beginning with water which is used most unproductively (water with the lowest marginal efficiency of production), and graduating to water with increasing marginal productivity.

Further, if the water in the entitlement market and the water traded as part of an irrigated farm were identical goods, and if both water markets operated efficiently, at least in the same location, the price of a given quantity of water should tend to equilibrium between markets. That is:

$$P_E = P_L$$

In essence, with arbitrage and zero transaction costs, market convergence should occur with 'the Law of One Price' applying (Goldberg and Verboven, 2001). As is well known, however, the absolute version of the Law of One Price is rarely observed. Transportation costs, barriers to arbitrage, imperfect information, differences in regional markets and state-based policy regimes, mean that different markets for even identical products do not perfectly integrate and prices are not observed to equalise perfectly. In the case of P_E and P_L, what is more likely is a form of 'relative' price convergence, where prices tend to equality within each regional market.

Unfortunately, actual data on the implicit price of water traded in association with land are difficult to establish, as it is not possible to observe P_L directly. If the characterization of the water markets along the River Murray is in accord with the previous discussion, however, a number of predictions can be made.

First, within any one region, although it is unlikely that $P_E = P_L$, it is likely that over time:

$$P_E = f(k + P_L) \qquad \text{where k is a constant.}$$

Further, that for either water market in each state:

$$PW_{SA} \neq PW_{Vic} \neq PW_{NSW}$$

where PW_{SA} is the price of one type of water in SA, PW_{Vic} the price of the same type of water in Vic and PW_{NSW} the price of the same water type in NSW.

Given the difference in supply reliability, the difference in high and low-value use, and the relative demand for water in each state and again considering the same water market, it could be predicted that, by state:

$$PW_{SA} > PW_{Vic} > PW_{NSW}$$

OBSERVED BEHAVIOUR

Allocation markets provide irrigators with an ability to adjust their water use during the season, depending on supply, demand, prices for final products as well as the level of precipitation and evaporation (Bjornlund and Rossini, 2005). They also, less obviously, allow irrigators a different option of exit adjustment; by selling the water annually and remaining on the property to maintain an income from water sales, undertaking off-farm work, and engaging in dry land farming (Bjornlund, 2002, 2004). Finally, the combination of the market for allocations and entitlements allows irrigators to adjust their risk exposure; they can buy entitlements to reduce their supply risk and then sell excess water during years where they don't need all their water, or else they can sell entitlements to generate cash and consequently rely more on purchases in the allocation market (Bjornlund, 2006c). Despite the predictions associated with efficient and well-integrated markets, for example, that prices of similar water should tend to equate in local markets, in practice, markets are not perfectly efficient and there are likely to be numerous practical impediments to the relationships predicted above.

Experiences with water markets in the early 1990s revealed that entitlement markets only transferred relatively low volumes of water, while allocation markets transferred up to 10 times as much (Bjornlund, 2004). Risk aversion among irrigators, imperfect information and institutional barriers can explain much of this. For example, in the early 'thin' markets, with few active buyers, sellers or intermediaries, participants were likely to have imperfect information about supply and demand, with the result that prices fluctuated widely and with little relationship to economic ‘fundamentals’ (Brown et al., 1982). Second, the level of uncertainty about the future of water entitlements varied over time. This uncertainty was (and to some extent, still is) caused by unsolved issues related to the environment and the need to maintain a certain level of water-flow, the lack of specification of property rights in water in existing legislation, and the impact of the Murray-Darling Basin Cap (MDB cap) (Bjornlund, 2005). This uncertainty was likely to increase the willingness of irrigators to trade in allocations rather than entitlements; in short, a ‘wait and see’ philosophy (Bjornlund, 2003a).

Third, most irrigated agriculture is quite capital-intensive in nature. Most irrigated farms with permanent crops have large investments in irrigation and drainage infrastructures. It has been argued that the income-generating potential of such water-dependent improvements has been capitalised into the value of associated water, since it is the essential precondition for the production generated by such improvements (Milleman, 1959; Hartman and Taylor, 1989). For a rational irrigator considering selling an entitlement to some quantity of water, the price received from selling the entitlement has to at least equal the net present value of the decrease in income that results from reducing the productive capacity of the farm. By contrast, farmers selling water which has not supported water-dependent infrastructure are likely to be willing to sell at lower prices, since they will not suffer any such decrease in the future income stream from lowered production. This factor is important because when the MDB cap was first set, the decision was made not to adjust entitlements to reflect actual prior use, resulting in large volumes of unused or only partly-used water entitlements (sleeper or dozer water). Unused water therefore dominated the early years of trading in the entitlement market (Bjornlund and McKay, 2000).

Related to this issue, buyers of irrigated land and water determine the price they are willing to pay for a property based on the expected income stream generated by that property (produced by the bundle of land, water and improvement components). If the irrigation system is inefficient, or the plantings on the property are of poor quality or of the wrong variety, the productivity of the water will be low, as will the income stream generated by the property. Improving irrigation systems, and improving or replacing plantings is costly, with many horticultural crops taking 6–8 years before commercial harvest. Buyers of properties in poor condition will discount the price paid for a property with an amount equivalent to the net present value of the lost income stream during that period. This relationship is likely to be most predominant within horticultural areas and least within areas with cropping and pasture-based productions with fewer water-dependent improvements and easier conversion between crop types. The price of water bundled with the land price is therefore likely to be influenced by the type and quality of the crop and improvements.

THE STUDY REGIONS

Information on the price and quantity of water traded in the market for water entitlements and water traded in association with land was gathered from the three states along the River Murray. It was anticipated that as entitlement markets emerged at different times in different states, the clearest examples of price convergence would occur in markets with the greatest difference in starting points (youngest markets) and be less observable in longer functioning markets (where price convergence was likely to have been established, at least to a degree). Among the three states in this study, NSW and Victoria had the least relative experience with entitlement markets and SA the longest. If the implicit price of water was associated with the value of crops and improvements on the land, then areas with higher levels of capital investment and valuable crops would exhibit more complicated relationships between the entitlement and implicit water markets than areas where the production processes were less capital intensive. Agricultural output involving the least intense mixture of water and capital investment was found in NSW. Slightly more intense (and complex) production processes were to be found in Victoria, while SA contained the highest proportion of farms with the most water dependent infrastructure.

The Riverland in South Australia stretches along the River Murray from Blanchetown to the South Australia-Victoria border. Water in this region is used mainly for horticulture and viticulture; these industries are very dependent on security of supply as the permanent plantings can suffer significant long-term losses if insufficiently watered. The allocation policies in South Australia have been very conservative, an embargo was placed on the issue of new entitlements very early and during the 1970s entitlements were reduced depending on history of use. These entitlements are therefore generally accepted to be 100 percent secure; that is, they will be delivered in full every year. This record has been broken only since 2006 when allocations have been below 100% due to exceptional drought.

The Central Goulburn Region is part of the Goulburn-Murray Irrigation District (GMID) in Victoria stretching along the Goulburn River on the way to its junction with the River Murray. Water here is mainly used on permanent pastures for dairy. While dairy farming is dependent on a high level of supply security due to significant investments in permanent pastures and dairy herds and equipment, it also has some flexibility by substituting growing grass by purchasing feed. Victoria, during the study period, provided two entitlements to water. Irrigators had a water right, with a security of delivery of 96 out of 100 years, and an annual sales-water allocation, which was announced every year as a percentage of the water right, depending on the availability of water in the storages. The long-term mean of sales-water was expected to be about 60 percent. An irrigator with a water right of 100 ML is therefore expected, on average, to have access to 160 ML. The high level of supply certainty of water rights is achieved by not announcing any sales water until the following year's water rights are secure in the storages. Victoria has seen allocation levels below 100% of water right only since 2002; also due to drought.

The Murray Irrigation Limited (MIL) in NSW stretches along the Northern bank of the River Murray opposite the GMID in Victoria. Water in this region is mainly used for rice production. This industry has the ability to adjust their water use from season to season depending on water availability without long-term implications. The water allocation policy in NSW has been very aggressive, with authorities continuing to issue new licenses much longer than in Victoria and South Australia, and allocating almost all available water each season, leaving little as security for the following season. Consequently, annual allocations fluctuate significantly and average out at about 74 per cent of entitlements (McGuckian et al, 2001). During the recent drought, these irrigators have seen seasonal allocations as low as zero percent.

DATA SOURCES

During the mid to late 1990s, water within all three states could be purchased in two ways, either as a separate commodity in the water market or as part of an irrigated farm in the farmland market. Hence the price in the two markets was established in different ways. In more recent years, property rights in land and water have been more clearly separated. As a consequence, in most states separate contracts are negotiated for land and water assets. The research presented in this study, therefore could not be carried out today.

The entitlement market

The explicit price paid for water entitlements in the water market was obtained by interviewing buyers and sellers. Transfers of water entitlements during the study periods were identified using the records of Goulburn-Murray Water in Tatura, MIL and the

Department of Land and Water Conservation in Deniliquin, the Department of Water Resources in Berri, and the Central Irrigation Trust in Barmera. These records did not include prices paid for water entitlements. To establish price, as well as personal and property specific information, buyers and sellers were interviewed via telephone, with 100 buyers and 100 sellers of water entitlements interviewed in each study region.

The irrigated farmland market

Transfers of irrigated farmland were identified using the records of the offices of the Valuer General in Adelaide, Melbourne and Deniliquin. These records include information about sales price and date of sale, as well as some property-specific data, information about the size of the entitlement included in the sale and actual water use was obtained from the water authorities as listed above. Sales were analysed within the SA and Victoria areas for 1994–96, and within the NSW area for 1997–99. The difference in time period between the States does not present a major problem, since the entitlement prices used for comparison within each State are from corresponding periods; however, it does mean that the market reported for N.S.W. is slightly more mature than the one reported for Victoria. Within Victoria and SA, 100 buyers of farmland were interviewed via telephone to establish personal and property-specific data. This was not done in NSW for two reasons: first, resource and time constraints, and second, most significant factors identified in the process of building the Victorian model were available from the records of the MIL.

Valuation for rates and taxes is conducted differently in NSW than in Victoria and SA. In NSW, rates and taxes are based on the unimproved value, while in the two other states they are based on the improved value. Hence the Valuer General's valuations in NSW do not include the value of improvements and consequently slightly different approaches had to be taken in the model building process.

METHODOLOGY

The price for water entitlements traded in the water market can be observed directly. Identifying the price of water that is tied to land, however, involves an indirect process, as it is the land sale price rather than the price of water that is observed. A standard method of 'unbundling' the factors that contribute to land price (and thus identify the contribution of water) is to estimate a hedonic price function for land. By estimating the hedonic function, coefficients are calculated (the implicit price of each of the bundled factors). Examined individually, these coefficients provide information about the relative price of each factor. In this case, the factor of most interest is water.

A small number of studies have previously used hedonic functions to establish the price of water when attached to land (Crouter, 1985; Hartman and Anderson, 1963; Bjornlund, 1995, 2001; Coelli et al., 1991; Bjornlund and O'Callaghan, 2005). In simple terms, the price of any commodity (Z) can be considered to be a function of its constituent parts. For example,

$$P(Z) = f(Z_1 \ldots Z_n)$$

where $P(Z)$ represents the observed product prices and Z_1 to Z_n represents the bundle of characteristics within the product. Solving this function for a large number of transactions will establish the value of each of the Z characteristics.

Unfortunately, it is unlikely that the value of water can be completely isolated and separately identified using this approach. For example, if Milleman (1959) is correct, and the income-earning capacity of water-dependent improvements are capitalised into the value of water, this would require an interactive variable between water and improvements be estimated. This would most likely be observed within areas with capital-intensive productions such as horticulture and viticulture. It could therefore be expected that the nexus between land and water would still exist in a 'value sense', even though they have formally been separated by law (Crouter, 1985; Hartman and Anderson, 1963). This suggests that the hedonic function estimated for each state will differ, depending on the predominant production process. For example, the estimated function for SA (very capital intensive productions) should be different from that estimated for Victoria or NSW.

The type of hedonic function that has been tested includes two groups of property characteristics: non-water-related (Zs) and water-related (Ws), plus interactive terms between these two categories (ZWs) measuring the interdependency between the water and non-water attributes. This can be expressed as:

$$P(Z) = \alpha_0 + \sum_{i=1}^{n} \alpha_i Z_i + \sum_{i=1}^{n} \beta_i W_i + \sum_{i=1}^{n} \gamma_i Z_i W_i + \varepsilon$$

where $P(Z)$ is the value of land, α_0 is the constant or intercept, α_i, β_i and γ_i are regression coefficients to be estimated, and ε is a normally-distributed stochastic error term.

Functional form and variable selection

Following the work by Coelli et al (1991) and Crouter (1985), it was decided to estimate a linear functional form. To proxy for implicit marginal prices, total product prices (in this case, total transaction prices) were used as the dependent variable (Griliches, 1971; Rosen, 1974). A large number of variables are potentially bundled into the price of a piece of irrigated farmland. Of these, we identified three main categories of value determinants: production factors, consumption factors and location factors.

A large number of variables may be used to proxy for land's productive capacity; from different land-classes, top-soil depth to measures of soil productivity such as soil categories (Peterson, 1986; Miranowsky and Hammes, 1984; Coelli et al., 1991). The ultimate determinant of which measure to use invariably depends on the availability of data and the rural activities in the area.

The presence of improvements, such as a dwellings and farm buildings, is also problematic. This paper adopts the total purchase price for land and improvements as the dependent variable and the assessed value of built improvements as an independent variable. If the coefficient for the assessed value of built improvements is not significantly different from one, this value is deduced from the total purchase price following the approach taken by Crouter (1985). This approach was not possible in NSW as the Valuer General provides unimproved valuations. For reasons outlined below, however, in NSW it was assumed that the value of built improvements was capitalized into the land value .

The Australian farming sector has traditionally been family-operated and the importance of the farming property as a consumption good is therefore significant (King and Sinden, 1988). This significance is further emphasised by the fact that many small farmers are increasingly depending on off-farm work to supplement farm income, instead of exiting and giving up the rural lifestyle (Bjornlund, 2002). Following King and Sinden (1988), a dummy variable, a proxy for the consumption attributes of the farm, was included to indicate whether an inhabited dwelling was present or not. The buyers' perception of the quality of the dwelling was also obtained through the survey. Clearly, proximity to markets, processing plants, grain storage facilities etc also influences the profitability of rural land as well as its consumption value. Most studies attempting to explain rural land values therefore include some location variables. This issue is potentially important within irrigation areas with relatively high population density, close proximity of town centres and significant demand for land for rural living or hobby farming. The importance of non-farming factors in the market can be related to the size of the property or its distance from a population centre (Drynan et al, 1983; Gardner and Barrows, 1985). The cut-off points used to exclude properties to eliminate the influence hobby farming in this study varied between study areas.[1]

In addition to the wide range of potential theoretical variables affecting the price of land, and the need to consider a number of different theoretical models, there are the usual econometric considerations such as the extent of multicollinearity, heteroscedasticity, and misspecification. Variance-decomposition tests were used to test for

[1] In the Riverland (South Australia) the minimum was set at 2 HA, within the Goulburn Murray Irrigation District (Victoria) at 10 HA and within the Murray Irrigation Limited (New South Wales) at 25 HA. These admittedly arbitrary differences reflect the variation in production processes, consequent general farm size and the population densities between the regions in the three states.

multicollinearity, the Breusch-Pagan-Godfrey test was used to test for heteroscedasticity, and the Ramsey Reset test was used to test for misspecification. The models discussed do not violate any of these assumptions using conservative testing values and in the selected models, the coefficients had the anticipated signs. The selection of the final model for each state was the result of careful theoretical considerations, practical constraints, statistical best fit, and not some little judgement. It is outside the scope of this paper to provide a detailed discussion of the model building process for each state.[2] As an example, however, the following section provides some details of the process followed within the Victorian study area.

MODEL BUILDING PROCESS

Victoria

Four different model specifications relating to the inclusion of land and water were tested. The first model used total property size, volume of water right, presence of unused water, and whether the buyer had purchased additional water subsequent to buying the property plus variables on the quality of dwelling, and distance to a major town. In essence, this approach assumes that all land has the same value in the absence of water. Model two included variables for land (dry and irrigated), volume of water right and the other previously mentioned variables. This assumes irrigated land has a different value from non-irrigated land. Both models were statistically significant and not in violation of the tested assumptions. The Davidson-McKinnon J-test suggested accepting model two over model one at the 0.1 significance level, while the test was inconclusive on the 0.05 level.

Model three focussed on the influence of the product being produced and model four on the location. The influence of product type was calculated by multiplying total water right by the proportion of each form of production on the property, while location was tested by multiplying dummy variables for location by water right. Testing the coefficients for the interactive variables between land use and water rights, and location and water rights proved that they were not significantly different. It was therefore decided to adopt model two as the preferred model.

[2] This is available on request from Bjornlund.

Table 1: Hedonic function irrigated farmland, Central Goulburn region in Victoria 1994–96.

Variable	β	se β
Irrigated land (ha)	910.50	224.44 ***
Water right (ML)	410.23	112.75***
Sales-water (ML)[1]	289.99	73.21***
Quality of dwelling (1–7)[2]	7,913.62	1,827.19***
Distance to town (km)[3]	91,332.94	38,331.69**
Valuer General's building value ($)	0.79	0.12***
Buy water (0,1)[4]	–20,434.22	12,089.58*
Constant	35,517.67	10,077.73***
SEE	35,065.56	
Adjusted R^2	0.85	
F	72.02	
N	86	

Significance levels: *** = 0.01; ** = 0.05; * = 0.10.
[1] water use in excess of water right, computed by subtracting the water right from actual water use. If a property had used less than its water right, the variable was set at 0;
[2] buyers were asked to rate the quality of the dwelling: 1 = very poor to 7 = excellent;

[3] The distance from the estimated location of the dwelling based on cadastral maps to the nearest town of approximately 10,000 people. Using reciprocal form.
[4] = 1 if the buyer bought additional water entitlement subsequent to buying the property.
Dependent variable = purchase price less the price paid for chattel as per transfer documen6

Two further modifications, however, were made. First, the variable for dry land was eliminated because it was associated with a very high standard error. Second, the variable 'unused water' was replaced by two variable 'sales-water' and 'unused-water'. The variable 'sales-water' measures how much water the irrigator use in excess of water right, if this variable is positive then the property must have the necessary improvements to use that 'sales-water', and if our assumption is correct, that part of the income earning capacity of improvements is capitalised into the value of water, then 'sales-water' should add value to the water right. On the other hand, if 'unused-water' is positive, then the property do not have the infrastructure to use the water right, and, if part of the income earning capacity of the infrastructure is capitalised into the value of water, then 'unused-water' should reduce the value of the water right. The sign of the two variables indicated that the anticipated value impact was correct. However, the coefficient of the variable 'unused-water' was insignificant. The final model in Table 1 therefore only includes the variable 'sales-water'.

The final model explains around 85 percent of the observed variation in land price, the coefficients have the anticipated sign, and most are significant at the 0.01 level. The model includes the following variables: irrigated land; water right; 'sales-water'; quality of dwelling; distance to town; Valuer General's estimated building value; and a dummy for buying water. The dependent variable is the property's total transfer price less the amount specified for plant and chattel in the transfer document.

New South Wales

The final model for NSW also separates land, water and improvement components (Table 2). To estimate the hedonic function, it was not necessary to interview buyers of farmland in New South Wales. A comparison of the variables available in the MIL database with the variables used in the model in Victoria suggested that little would be achieved by interviews. Furthermore, the only variable not available in NSW was the rating of the dwelling. Discussions with irrigators indicated that most farms are purchased for farm amalgamation, and in such instances, dwellings are considered a liability more than an asset, as there is no or little demand for rental properties. The demand for hobby farms and life-style properties also appears to be lower than in Victoria. Unfortunately in NSW, council rates are based on unimproved values, and the Valuer General's file does not include improvement values. It was therefore not possible to include this variable, as in Victoria and SA.

Table 2: **Hedonic function irrigated farmland, MIL, New South Wales 1997–99**

Variable	β	se β
Total entitlement (ML)	405	47***
Water used for permanent pastures (ML)	450	65***
Area (ha)	344	78***
Within Wakool (0,1)[1]	–186,398	30,159***
Within Deniboota (0,1)[2]	–110,735	29,780***
Constant	58,837	24,987**
SEE	94,145	
Adj. R^2	0.75	
F	61.146	
N	104	

Significance levels: *** = 0.01; ** = 0.05; * = 0.10. [1] if property located within Wakool = 1; [2] If property is located within Deniboota = 1. Dependent variable = total purchase price

Estimates that included interactive variables between water use and crop type showed that the differences between the coefficients for the individual crops were insignificant, except when the water was used for permanent pastures. The final model was significant overall and explained 75% of variance in price. The included variables are significant at the 0.01 or 0.05 level and have the anticipated signs. The final model (Table 2) includes the following variables: total water entitlement; water used for permanent pastures; land area; location within the Wakool area and location within the Deniboota area. Unlike Victoria and South Australia, however, it was not possible to obtain information about the price paid for plant and chattels.

South Australia

The model specification process for SA was far more involved than for the other states, due to the more capital-intensive nature of the properties, most of which have extensive horticultural plantings and irrigation systems. The model building was also complicated by considerations of the age and variety of any plantings, the current stage in the farms ‘life cycle’ of production and the costs of changing production techniques. To produce proxies for these factors, each buyer was asked to provide information as to their perception of the quality of plantings and irrigation systems. Eight different models were tested (see Bjornlund, 1999), some separating land, water and improvement factors, and others using different interactive variables between these factors of production and their perceived quality. This process established that a model that reflected interactive variables between crop type and water entitlement, and planting quality and water entitlement, was superior to those separating the land, water and improvement components, or using interactive variables between land use and land area. The final model does not include land area, suggesting that the important determinants of irrigated farmland values within an area with high value, capital-intensive production, with slow and costly processes of changing production, and with very low natural precipitation, are the water, the type and quality of plantings and the irrigation system. Since these capital investments are lost if water is removed, their total value is linked to the value of the water. The model finally selected contained coefficients having the expected signs, with most being significant at either the 0.01 or 0.05 levels. The function was also able to account for about 71 percent of the observed variation in land price. The model, detailed in Table 3, includes the following variables: water entitlement for citrus; water entitlement vines; water entitlement other plantings; unused water entitlements; quality of the dwelling; quality of the irrigation system; quality of plantings combined with water entitlement; building value; perception of price; water table problems; and months since sale. In this state, the dependent variable is total purchase price less the price paid for chattel, as specified in the transfer document. The distance variables proved to be insignificant, possibly due to the relative closeness of the towns in the Riverland.

Table 3: Hedonic Function irrigated farmland, the Riverland, South Australia 1994–96

Variable	β	se β
Water entitlement used on citrus (ML)	176.85	92.7**
Water entitlement used on vines (ML)	383.84	72.8***
Water entitlement used on other plantings (ML)	478.24	183.1***
Unused water entitlement (ML)[1]	–279.52	88.0***
Quality of dwelling (rated 1–7)[2]	2,395.27	1,531.8*
Quality of planting*water entitlement[4]	38.17	13.6***
Quality of irrigation system (rated 1–7)[3]	2,314.85	1,169.9**
Valuer General's building value ($)	0.69	0.11***
Perception of price (–3 to +3)[5]	3,091.36	1,800.2*
Water table problems (rated 1–7)[6]	–2,683.73	1.258.4**
Months since sale[7]	–1,023.04	291.3***
Constant	54,306.82	8,342.9***
SEE	22,966.63	
Adj. R^2	0.71	
F	22.57	
N	96	

Significance levels: *** = 0.01; ** = 0.05; * = 0.10.
[1] computed by subtracting actual water use from the total entitlement;

[2] buyers were asked to rate the quality of the dwelling: 1 = very poor to 7 = excellent;

[3] as for quality of dwelling;

[4] Interactive variable between quality of planting (rated as for dwelling) and water entitlement.

[5] Buyers were asked to rate how they perceived the purchase price: -3 = very cheap to +3 = very expensive.

[6] Within some areas of the study region, high water tables and water table salinity are problems which impact on productivity. Buyers were therefore asked how they perceived water table problems on the property: 1 = no problem to 7 = severe problem.

[7] Preliminary analysis indicated that there had been a price increase during the study period: 1 = the last month to 33 = the first month of the study period

Dependent variable = purchase price less the price paid for chattel, as per the transfer document.

RESULTS

New South Wales

The simplest hedonic model estimating the implicit value of water is for NSW. Figure 1, therefore, plots the individual prices traded on the entitlement market and the estimated implicit value of water, together with its confidence interval. Between 1997 and 1999, the implicit price of water either unused or used for all purposes other than permanent pastures, is estimated at $405/ML with a 95% confidence interval ranging from $311 to $499. Mean prices paid on the entitlement market for the same period increased from $298 (with a standard deviation of ± $81) in 1997 to $404 (± $58) in 1998 and $414 (±$75) in 1999. Casual inspection of Figure 1 suggests that the prices in the markets for entitlement and 'implicit' water tended to converge over the period. A closer look at the prices paid in the entitlement market indicates that during 1997 more than half the water was sold for less than $311/ML, the lower confidence bound for implicit water. Since 1998, however, almost all the entitlement transfers were priced within the 95% confidence interval of the implicit water price. These figures are suggestive of a possible initial depressing impact of underutilised water (so called sleeper or dozer water) on prices of entitlements, and since 1998, as less sleeper and dozer water remained to be traded and farmers' awareness of the value of water increased, that prices paid in the entitlement market moved toward the implicit value of water when attached to farmland. There would appear to be circumstantial support for the idea of convergence between the two markets such that P_E tends toward P_L.

Figure 1: Explicit and implicit water prices 1997-99, Murray Irrigation Limited, NSW

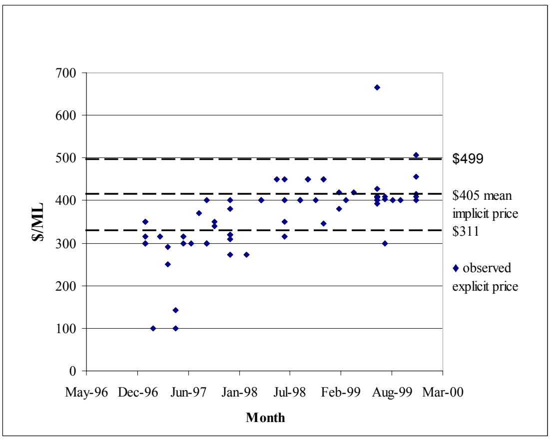
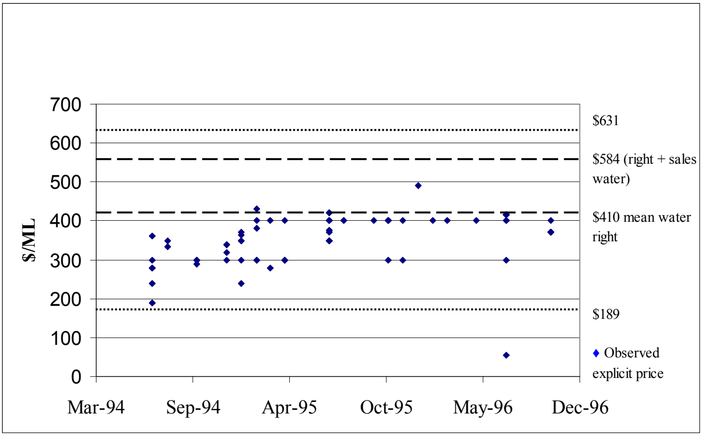


Table 2 also suggests that for those properties where water is used on permanent pastures (typically dairy farms), the implicit price of water rises by $450/ML to $855. Note that as dairy production requires capital investment in fencing, stock watering, dairy equipment and dairy herd; the higher price for water associated with permanent pastures suggests that the income stream generated by these improvements may be capitalised into the value of water. By comparison, the major reason for land purchases in this area, expansion of rice farms, also involves investment in infrastructure, such as laser grading and other soil preparation. The analysis however suggests that the value of this infrastructure has largely been written off by the buyers. This is supported by anecdotal evidence which suggest that over this period most purchases were of farms with 'inefficient layouts' bought with the intention to redesign the farm layout and amalgamate it with the buyers existing property.

Victoria

Figure 2 represents the price outcomes for Victoria. The coefficient for 'water right' derived from this region's hedonic function (Table 1) indicates that the implicit price of water, when attached to land, (W_L) is approximately $410/ML with a 95% confidence interval from $189 to $631. As Figure 2 illustrates, all water prices in the entitlement market fell within the 95% confidence interval of the implicit water price over the period 1994 to 1996. Just as clear, however, is the observation that almost all the entitlement prices fell in the lower end of the confidence interval, with a mean price in the entitlement market of $357/ML and a range from $190 to $490. However, this comparison does not fully reflect the value of water when attached to land since each water right, has an attached sales-water component with an estimated implicit value of $290 per ML if used. Since sales-water is less secure than water obtained under water rights, it is logical that it has a lower value. Based on the expected future mean level of sales-water of 60 percent, an additional $174/ML (0.6 of $290) has to be added to the estimated value of W_L of $410 when comparing with W_E. This increases W_L to $584/ML.

Figure 2: Implicit and explicit water prices 1994-96, Central Goulburn Region, Victoria



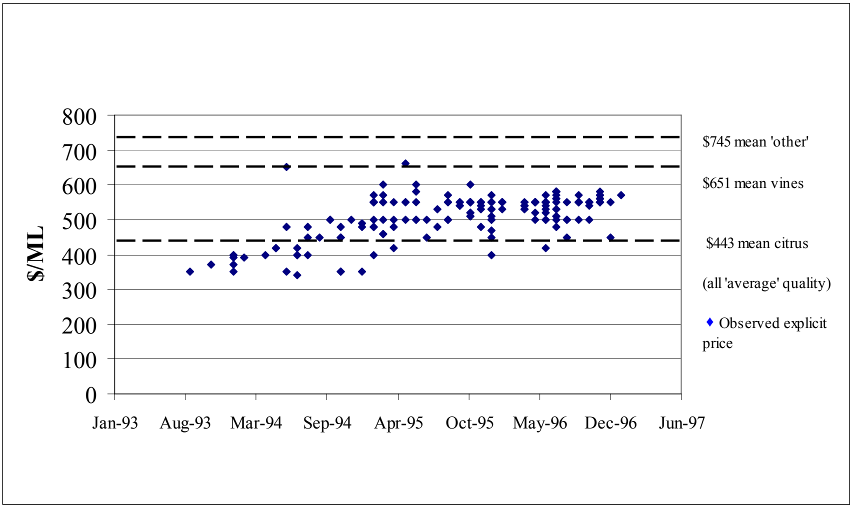
The variable, 'buy water', indicates that if additional water was bought on the permanent market after the purchase of the property, the price of the property was reduced by $20,434. This again emphasises the importance of water as a value determinant. It also indicates that the price of $910/ha of irrigated land is based on there being sufficient water available, suggesting that part of the income-producing capacity of water has been capitalised into land value. It is arguable, therefore that the $584/ML underestimates the true value of W_L.

This discussion indicates that even though, in theory, the hedonic function is separable into land and water components, the coefficients of the two variables are not easily partitioned. Nevertheless, Figure 2 is suggestive of a water market where permanent prices are still converging toward the implicit (W_L) price, albeit with some considerable distance to go. Possible reasons for this sluggish convergence, particularly in comparison with NSW, are differences in the production processes in both regimes (with rice dominating in NSW and dairy farming in Victoria), and differences in farmers' perceptions of the security (reliability) of water allocations. The hedonic function for Victoria, as in NSW, is supportive of a link between implicit water prices, production processes and capital investment. Analysis by Bjornlund and O'Callaghan (2005) clearly show that permanent prices increased significantly since and tended to converge with W_L after 1997 and that during the increased drought of 2002/03 W_E exceeded the upper bound of the 95% confidence interval of W_L.

South Australia

Compared to both NSW and Victoria, the area under consideration in SA is both more capital intensive in production and has greater experience with the entitlement market. The more complex hedonic function estimated for SA reflects this, as do the relative values of particular variables it contains. As Table 3 suggests, the implicit price of a water entitlement when attached to a citrus grove is worth $177/ML, while if it is attached to a vineyard it is worth $384/ML, and to other horticultural plantings (usually vegetables or almonds) $478/ML. It also suggests that where a water entitlement is not fully taken up, this has a negative influence of $280/ML. As with the Victorian case, this suggests that the value of the productive capacity of water-dependent infrastructure has been capitalised into the value of water in use.

Figure 3: Implicit and explicit water prices 1994-96, Riverland, South Australia



The hedonic function also permits the calculation of the impact of the relative quality of plantings on the implicit water price. If the decision to purchase water entitlements is affected by the relative quality of plantings (i.e. farmers with higher quality and more valuable crops pay more for water entitlements), it is possible that this can be detected by comparing entitlement prices with implicit water prices for average value crops. Figure 3 illustrates the situation where permanent water prices over three years are compared with the implicit price of water for farms with the average quality plantings (4 x $38.17) of citrus, vines and other crops. The implicit value of water for farmers with 'average' crops appears to be broadly in line with permanent water prices. Note also that if the implicit price of water is calculated when top quality plantings are considered, vines and 'other' crops have a consistent and strong incentive to purchase water on the market for permanent water, while for citrus, (where the implicit price of water for top quality crops averages $443) there is far less incentive to purchase permanent water. On the other hand, irrigators with unused water and low quality plantings, especially if they are citrus, would appear to have an incentive to sell on the entitlement market.

Figure 3 reflects a more mature entitlement market in SA than either NSW or Victoria and does appear to provide further evidence for the view that the implicit water price and entitlement price will tend to converge over time. This further suggests that as markets mature, economic factors such as the type and quality of plantings and the extent and quality of capital investment will be influential on market prices.

CONCLUSIONS

This paper has analysed some of the available data on prices in the entitlement market in three states in Australia over the mid to late 1990s, while land and water was still predominantly traded as one asset and while the volume traded in the entitlement market was slowly growing. This period therefore offers a unique opportunity to analyze the convergence of implicit and explicit water prices. It has also been able to construct, using hedonic price functions, values for the implicit price of water in these same regions over the same period. Despite the limited nature of the data, there is evidence that in the early years of water markets along the River Murray, the price for water entitlement and the implicit price of water estimated from land sales were tending to converge. Time series data within New South Wales and Victoria appear consistent with the notion that prices in the entitlement market and the implicit price of water derived from land sales tended to converge, while the evidence from South Australia, the state with the most established market for entitlements, reveal that water prices in both markets tended to move together. There is also evidence to suggest that the value of capital improvements, crop types and other forms of productive investment affect implicit water prices.

The evidence also suggests that in line with expectations, prices for entitlement and implicit water differ between states. On the entitlement, market prices were generally highest in South Australia and lowest in New South Wales, while a similar although more complex trend by state is observable in the implicit water markets.

Other expectations consistent with economic theory are also supported. For example, in New South Wales, the hedonic function was totally separable into land and water components. The income-earning capacity of water-dependent capital improvements appears not to be capitalised into water unless used for permanent pastures (dairy production). If not for dairy, it appears that the income-earning capacity of water-dependent farm improvements has been written off. This is consistent with anecdotal evidence and the fact that the predominant water use in the area is for rice, which is less capital intensive and with farm improvements adaptable to other productions.

In Victoria, it was found that irrigators selling water on the entitlement market were receiving less for the water than the resulting loss in property value. Prices in the entitlement market were also far less than the value achieved by combining the implicit price of water derived from water rights and sales-water. This suggests that entitlement prices had some capacity to increase- something history has confirmed. The hedonic model, however, was not easily separable into land and water components given the more capital-intensive nature of the dairy industry, which is the predominant water user within the area.

In South Australia, it was found that unused water, when sold together with irrigated farmland, had a much lower value than water actively supporting production. This was likely due to the fact that if actively-used water was removed from the land, water-dependent capital infrastructure would lose its income-earning potential and thereby its value. This is consistent with the theory that the income-earning potential of water-dependent farm improvements is capitalised into the value of the water on which they depend. Further, comparing the implicit price of unused water when attached to irrigated farmland with prices paid for water on the entitlement market, showed that sellers of unused water received a price well in excess of the potential loss in property value. Also, in South Australia, where irrigation is most capital-intensive, land, water and improvements cannot be separated in the hedonic function. Water's value appeared to be interrelated to the type and quality of the plantings on which it was used and the irrigation system by which it was applied. For example, the relative prices of entitlements and implicit water prices suggested there was an incentive for farmers with low quality citrus plantings to sell water, and irrigators with high quality vines or vegetable crops to purchase water entitlements.

Anecdotal evidence suggests that market participants were becoming aware of the price gap identified in Victoria between the explicit and implicit price of water entitlements and the arbitrage opportunities that this represented. Land is now being exchanged purely for the water rights attached. This has especially taken place within areas with degraded land where properties are being traded for higher prices than their productive capacity warrants and with a reduced incentive for the purchaser to restore the land. Evidence is emerging that land purchased by absentee landowners purely for the water entitlement may also result in farming communities being 'hollowed out' as purchased land is left idle and subsequently becoming infested by weed and pests that spread to neighboring farms. Since this period, research has shown that in Victoria the explicit and implicit prices continued to converge and in some time periods, driven by the forces discussed above, the explicit price actually exceeded the implicit price. The implication of this for valuers, especially when valuing for mortgage and market purposes, is that they need to consider carefully the relationship between land, water and improvements and their conditions. In some instances, the value of the water actually exceeded the value of the land *and* water. Hence for mortgage purposes, it is essential to ensure that a mortgage is registered against the water entitlement rather than the land holding.

The 1990s were the decade when water markets first began to emerge along the River Murray. Hopes were high that the market would be a useful and equitable policy tool to assist in the reallocation of a scarce resource toward efficient and high value production and away from inefficient and low value products. The limited data available over this period support the interpretation that market forces were beginning to achieve the desired outcome. The findings in this paper however also suggest that when unused water entitlements were left in the system when trade was introduced, the markets may not have provided the equitable outcome anticipated. Prices in the market were driven by sellers of unused water with the result that farmers selling actively used water were receiving less for the water than the consequent reduction in farm value. These findings have implications for rating and taxing valuers struggling to come to terms with separating land and water values. The findings both in South Australia and Victoria suggests that simply allocating value to water entitlements based on prices paid in the entitlement market will not be appropriate.

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